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ABSTRACT

The present work of Stanford University's Institute for Mathematical Studies in the Social Sciences (IMSSS) is based on earlier experience in the design, implementation, and administration of computer-assisted instruction (CAI) for deaf students. It is primarily concerned with modifying the mathematics program to make it more appropriate for deaf students and with developing a new language arts program for deaf students at the junior high school level. Related research is also being done in the field of learning theory and psycholinguistics. A description of the progress made in these areas is preceded by a brief history and overview of the CAI project at IMSSS. (JY)

ANNUAL REPORT

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COMPUTER-ASSISTED INSTRUCTION FOR THE DEAF AT STANFORD UNIVERSITY

Jamesine E. Friend
Institute for Mathematical Studies in the Social Sciences
Stanford University
Stanford, California 94305

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I. Introduction

In June 1970 the Institute for Mathematical Studies in the Social Sciences (IMSSS) at Stanford University received a grant from the Bureau of Education for the Handicapped of the United States Office of Education to design, implement and administer computer-assisted instruction (CAI) for deaf students. Up to this time, all previous CAI programs at IMSSS had been written for normal-hearing children and adults. In 1968, however, it was suggested that the IMSSS CAI course in elementary mathematics might be appropriate for use by deaf students, and during the 1968-69 school year, the first deaf students at Kendall School used the mathematics course. In 1969, in association with the Kendall School and the nearby Model Secondary School for the Deaf (MSSD), the Institute initiated a pilot study on the use of CAI as a vehicle to teach language arts to deaf students.

The present project is based on that pilot study and on the experience gained from the mathematics project at the Kendall School in 1968. This project is primarily concerned with mod ying the mathematics program to make it more appropriate for deaf students and with developing a new language arts program for deaf students at the junior high school level. Related research is also being done in the fields of learning theory and psycholinguistics.

1. A Brief History of CAI at Stanford

Under the direction of Patrick Suppes and Richard Atkinson, both members of the Stanford faculty, IMSSS, in January 1963, began a program of research and development in CAI. Various research projects have been supported by the Carnegie Corporation of New York, the United States Office of Education, the National Science Foundation, the National Aeronautics and Space Administration, and the Office of Naval Research.

The first operational instructional program available in any form at all was a program in elementary mathematical logic. This program was first demonstrated on December 12, 1963, and two lessons consisting of 23 problems were run with four sixth-grade students on December 20, 1963. Some 20 lessons giving a fairly detailed introduction to sentential logic were written and programmed during the spring. In the summer of 1964, these lessons, which were presented on the scopes, were run with two fifth-grade boys.

During the spring of 1964, preliminary experiments using first-grade mathematics material were also conducted in the Institute with 29 kindergarten children. Throughout 1964, staff members worked to write and code CAI programs for first-grade and fourth-grade mathematics and for mathematical logic.

During the fall of 1964 developmental work continued on both the first-grade mathematics program and the logic program. Two groups of

first-grade children used a preliminary version of the mathematics program throughout the 1964-65 school year. During the spring of 1965, 41 fourth-grade children were given daily arithmetic drill-and-practice lessons by remote control on a teletype machine in their classroom at Grant School in the Cupertino Union School District. This installation constituted an important first step in moving terminals from the Stanford campus to elementary schools, with direct connection from the computer to the terminals by telephone lines. During the summer of 1965, 26 capable second-grade children worked through a revision of the logic course. The major revision in the course was designed to determine whether the use of English sentences or abbreviated logical symbolism was easier for the students.

During the 1965-66 school year, drill-and-practice teletype programs were conducted in three schools. Two teletypes at Grant School and one at Sequoia Union High School were used for arithmetic drill-and-practice programs. During the spring of 1965, four teletypes were used for drill-and-practice work in spelling at Costano School in Ravenswood City School District. Audio was provided from the Institute's central computer facilities by a second telephone line and earphones.

In the summer of 1964, IMSSS was granted a contract by the United States Office of Education to investigate the feasibility of teaching mathematics and reading as an integral part of an elementary-school program by using individualized, tutorial CAI over an extended period. The site chosen was the Brentwood Elementary School (Ravenswood City School District) in East Palo Alto, California. The Brentwood Laboratory was used to teach mathematics and reading to elementary-school children and to collect data on their learning behavior. The first students were run on the system at Brentwood on October 27, 1966, and by the end of the 1966-67 school year, over 100 children had participated in the project. This number included all the first-grade students at Brentwood. Half the students had daily CAI in mathematics; the other half, in reading.

In addition, the drill-and-practice program was expanded during the 1966-67 school year. Several more schools near Stanford installed teletypes. In March 1967, two teletypes were made operational at the Morehead State University Laboratory School in Morehead, Kentucky, more than 2,000 miles from Stanford. Then, on June 15, a summer session began in elementary schools in Kentucky, in which 28 teletypes were used for arithmetic drills. Teletypes were used for Grades 1 through 6. Students from one Morehead State University Upward Bound program participated in the program, and teletypes were also in operation at Breckenridge and Rowan County High School. (The terminals in Kentucky were connected by telephone lines to the Institute's computer at Stanford.)

Seventy-three students continued in the 1967-68 tutorial mathematics program at the Brentwood Laboratory. A new mathematics curriculum was initiated for the second grade.

Fifteen students in Grades 2 through 6 participated in the dial-a-drill program. Students in their homes were given oral exercises in elementary mathematics by means of computer-generated speech and responded by using a touch-tone dialing pad, which is now standard equipment on telephones in many parts of the United States. This was the Institute's first operational experience of bringing computer-based curriculum into the homes of students rather than into the schools.

In September 1967, 30 students at Stanford University enrolled in a course of computer-based elementary Russian for credit. The control class received regular classroom instruction, attended the language laboratory, and submitted written homework assignments. In the computer-based instruction class, regular classroom instruction was eliminated and work at Model-35 teletypes with Cyrillic keyboard and audiotapes with earphones was substituted. At the end of the first year, the computer-based students performed at a statistically significantly higher level. Perhaps equally important as the superior performance was a much smaller dropout rate for the computer-based section than for the regularly taught sections of the course.

The drill-and-practice mathematics program expanded again during 1967-68. From the end of January 1968, to the end of May 1968, the enrollment jumped from 2,387 to 3,823 for schools in California, Iowa, Kentucky, and Mississippi. The Iowa students were high-school age girls and older who worked on the drill-and-practice mathematics program in the Job Corps Center in Clinton, Iowa. In Mississippi, elementary-school students used both the mathematics drill-and-practice program and the logic and algebra programs.

In the fall of 1968, major emphasis shifted from tutorial programs to drill-and-practice programs in elementary mathematics and reading. The total number of students enrolled in the drill-and-practice program in elementary mathematics grew to over 6,000 during the 1968-69 school year. A remedial mathematics course for college students was prepared and run with students at Tennessee State University. During the 1968-69 school year, the system was expanded to include students in the Special Education Unit of the University of Washington in Seattle and students in the Kendall School for the Deaf in Washington, D.C.

In the 1969-70 school year, there were fewer terminals running in the Stanford CAI system, both because two of the major centers (Kentucky and Mississippi) continued with systems of their own and because there was a decrease in Federal support to other schools. During the summer of 1968, a major revision began of the drill-and-practice program in mathematics. The revised program evolved when attention was diverted from a program that could duplicate and expedite classroom procedures for a given grade to a program that could provide the most efficient drill for a given individual from the start of Grade 1 through the end of Grade 6. Attention to the child rather than to the classroom led to a reorganization of the drill-and-practice material in elementary-school mathematics into ungraded strands. This program is described more fully in Section III.

On Monday, May 18 and Friday, May 22, 1970 the Institute made what is perhaps the first use of a communication satellite to distribute CAI. The demonstration was important because it proved that satellite distribution of CAI through low-cost satellite ground stations had the potential for making CAI as accessible to isolated rural areas as to large cities.

2. The Stanford CAI System

The central processing unit for the Stanford CAI system is a Digital Equipment Corporation PDP-10 computer. The PDP-10 currently has a memory capacity of 196,608 (192k) 36-bit words and a memory cycle of 1.0 microsecond; thus, the contents of any of the 196,608 locations can be retrieved in one one-millionth of a second. Information sent to user terminals is processed by the PDP-10 processor and is placed into core memory buffers. From core these data are handled by the High-Speed Line Multiplexer, a special purpose computer serving as the interface between the central processor and the data transmission lines to terminal user sites. This Multiplexer performs all the tasks necessary to monitor the data received at and sent from the central Stanford system: formatting, timing, directing, and transmitting the data. The transmission of data can be accomplished via one of several user connections to the Multiplexer: direct, on-campus lines; dial-up data sets; or modem and phone lines.

At the terminal locations, the data sent from Stanford are handled by another small computer, the Micro 800, with multiplexing functions analogous to those of the High-Speed Line Multiplexer. At the Texas School for the Deaf, for example, the incoming data, demodulated by the data modem, are presented in a binary serial-bit stream, at 4800 bits per second, to the Micro 800. The Micro 800, sharing the same room with the 15 teletype terminals, has channels wired to each of these teletypes. The received data stream contains addressing information followed by a teletype character for a given teletype (as indicated in the address). For example, suppose the data coming from Stanford at a given moment indicate the letter "A" following the address just received for teletype #1. The Micro 800 "switches" the data coming in from Stanford buffer #1. The letter "A" is deposited in this buffer and the Micro 800 goes about reading subsequent addresses and filling the appropriate buffers. Meanwhile buffer #1 empties its contents at a much slower rate onto teletype channel 1. The result is that teletype #1 prints the letter "A."

3. The Student and the System

One important link in the CAI system, the connection between the central processor and the user terminals, has been described in the preceding section. Another important link in the system, the interaction between the student and the teletype, is described below. The third important component of the system, the CAI curriculum, is discussed briefly in the next section.

In a typical school, one room houses from 10 to 15 teletypes. A proctor usually monitors this room while the terminals are in use by

assisting and supervising the students, and handling minor technical problems with the teletypes. As the students usually arrive at the terminal room with their teacher, and other members of their class, they sit down at free terminals and begin their lessons for the day. The terminals are standard Model-33 teletypes and are essentially simple electric typewriters with the ability to send and receive code over telephone lines.

To begin a lesson, the student pushes a "start" key to let the computer know someone is there and ready for attention. The computer responds by typing

```
HI
PLEASE TYPE YOUR NUMBER AND NAME.
```

after which the student types his student number and his first name. Each student is given a unique student number when he is initially registered for CAI, so the request for the first name is merely an additional safeguard to ensure that the computer can correctly identify the individual student.

A student may be enrolled in several different CAI courses, perhaps for mathematics and language arts, but he does not need a different student number for each course. He keeps the same number for all courses and uses a one-letter course identifier to let the computer know which course he wants. Here the student is using the letter G, the identifier for one of the language arts programs:

```
HI
PLEASE TYPE YOUR NUMBER AND NAME.
G3456 MARY
```

Within a fraction of a second the computer searches the student file, locates and prints the last name of that particular student. In that same period of time the computer finds out exactly what work the student has done previously in the course and determines where he should start that day's lesson.

```
HI
PLEASE TYPE YOUR NUMBER AND NAME.
G3456 MARY SMITH

   //CHOOSE THE CORRECT PRONOUN.

I LIKE THAT GIRL.
I LIKE (SHE, HER).
```

After the computer types an exercise, it waits for the student to respond. If the student response is correct, the computer recognizes the correct answer immediately and gives the student a new exercise. If the student responds incorrectly, he is told immediately that he is wrong. Usually he is asked to try again, and sometimes he is given a

special message based on his incorrect response. After a certain number of attempts (the number varies from program to program) the computer types the correct answer for the student.

While one student is interacting with the computer in the manner described above, hundreds of other students across the United States are also seated at teletypes executing different lessons. Each is in direct, individualized communication with the same central processor at Stanford University. The computer can spend a fraction of a second with one student, switch immediately to the next student and continue down the line until it is back in communication with the first student again, having stored a complete record of its exchange with every student. This circuit is made so quickly that each student has the impression he is receiving the full, undivided attention of the computer.

4. Stanford CAI Curriculum

No two CAI courses have identical structures. Some are written as a sequence of separate lessons; others generate a unique set of problems for each student daily. Some have a complex branching matrix; others are predominantly linear. Some include many specific wrong-answer messages, others, none. Some provide tutorial instruction; others, drill and practice. However, a feature common to all Stanford CAI courses is individually tailored instruction. The student works at his own speed, receives immediate reinforcement or correction of his responses and encounters material consonant with his learning requirements.

Each student's route through a curriculum is unique. By virtue of frequent performance checks internally executed by the program, each unit of instruction or drill functions as a test determining the selection of each successive unit within that conceptual area; thus the material presented to an individual student is based upon his own performance. Even in those few essentially linear courses where all lessons are presented sequentially, the student is branched around the bulk of the problems within a given lesson if his performance on the initial problems warrants it. Not only are the specific exercises a student encounters individually determined, but within a single problem the student may receive a range of possible instructions and messages in accordance with his responses.

The CAI curriculums developed at the Institute over the past nine years span the following diverse fields:

Curriculums	Length of course	Grade level
Initial Reading (Strands)	3 years	K-3
Arithmetic Problem Solving	3 years	4-6
Mathematics Drill-and-Practice (Strands)	7 years	1-7
Logic and Algebra	2 years	7-9
Computer Programming (BASIC)	1 semester	High School
Russian	2 years	College
Computer Programming (AID)	1 semester	College
Basic English	1 semester	College
Logic and Algebra	1 semester	College

In addition, the following are among those currently under development:

Curriculums under development	Length	Grade level
Algebra	1 year	High School
Language Arts for the Deaf	2 years	7-9
Transformational Grammar for the Deaf	1 semester	High School
Conversations for the Deaf	--	1-12
Elementary Statistics	1 year	College
Elementary French	1 year	College

II. Participating Schools, 1970-71

The schools and school districts that have participated in this project from June 1970 are:

California School for the Deaf at Berkeley, California
Kendall School for the Deaf, Washington, D.C.
San Jose Unified School District, San Jose, California
Texas School for the Deaf, Austin, Texas

During the school year another school and another school district joined the project:

Model Secondary School for the Deaf, Washington, D.C.
Palo Alto Unified School District, Palo Alto, California

The California School for the Deaf and the Texas School for the Deaf are both State residential schools. (The California School for the Deaf also has a campus in Riverside, California.) Kendall School is a day school. MSSD has primarily day students, but it will eventually become a residential school. Both Kendall and MSSD are located on the campus of Gallaudet College, and some Gallaudet prep students have also used the CAI programs. Both Palo Alto Unified School District and San Jose Unified School District have day classes for deaf students in several schools. In Palo Alto 8 day classes in three different schools participated in the project and in San Jose 11 day classes in four schools participated.

At the beginning of September 1970, Kendall School started operation with four teletypes, and by the end of September, 100 Kendall students were registered. At the beginning of November, eight additional teletypes were installed at Kendall. Eight teletypes were installed at MSSD, and 78 students were registered.

Early in November an IMSSS staff member, Max Jerman, a specialist in mathematics education and CAI, went to Kendall and MSSD to conduct teacher-training workshops for the mathematics strands program. During the first week of February, Jamesine Friend visited Kendall and MSSD to orient the teachers and proctors on the language arts program. Kendall had a full-time proctor who was also in charge of other programmed instruction used at the school. She was assisted by two half-time proctors and by several of the Kendall teachers. There were no proctors at MSSD during most of the year, since the proctor duties were shared by several teachers. In March, however, MSSD did hire four Gallaudet College students to work as part-time proctors.

Early in December, the proctor and one mathematics teacher from the California School for the Deaf at Berkeley came to Stanford for three days' training, and during Christmas vacation, IMSSS staff installed ten teletypes at Berkeley. During the first week of January a teacher-training workshop for the mathematics strands program was conducted at the school, and 337 Berkeley students were registered for CAI in mathematics. Early in March another five teletypes were installed (in a different room), and on March 9, Jamesine Friend visited Berkeley to explain the operation of the new language arts program and to help the students get started on that course.

The Texas School for the Deaf began operation in January, and during the first week of January, the Texas proctor came to Stanford for training. During that week she also visited Berkeley to see that system in operation. By the end of January, 230 students at the Texas School were registered, and Grace Kanz, an IMSSS staff specialist in the mathematics strands program, went to Texas for three days to hold a teacher-training workshop. During the first week of February, another teacher-training workshop was held at the Texas School on the language arts program, and Texas students began using that course shortly thereafter. There were 15 teletypes at the Texas School and one full-time proctor.

At the end of January, deaf students at three public schools in Palo Alto joined the Stanford CAI system. Nine students at Cubberley High School, 26 students at Greendell Elementary School, and 16 students at Ray Lyman Wilbur Junior High School were registered. Both the Cubberley and Greendell students used three teletypes located in a trailer at Greendell School. There was one teletype at Wilbur Junior High. Two IMSSS staff members held a workshop on the mathematics strands program for the Palo Alto teachers at the end of January. Ten days later, another workshop was held to answer questions and to introduce the language arts program. There have been two follow-up workshops since then. All training for the Palo Alto teachers has taken place in joint meetings at Greendell School.

In February, four public schools in San Jose joined the project. Nine students at Bachrodt Elementary School, 12 students at Hester Elementary School, 8 students at Hoover Junior High School, and 9 students at San Jose High School were registered. Bachrodt School and Hester School each had two teletypes; San Jose High School and Hoover Junior High School each had one. At the beginning of February, an IMSSS staff member visited the four San Jose schools to explain to the teachers the operation of both the mathematics strands program and the language arts program. The teletypes were located in the classrooms, and since there were no proctors at any of the schools in San Jose, the teachers handled the scheduling.

In March, 128 prep students at Gallaudet College registered for CAI courses. As mentioned earlier, they used the teletypes already on the campus for Kendall and MSSD students; they used the teletypes only during the late afternoons and in evenings. No special teacher training was given at Gallaudet.

After the initial registration, a few additional students were registered at each school, bringing the total number of deaf students who have used the programs this year to over 1,000. Table 1 shows the number of students registered for the Stanford CAI system by month and by school; totals are shown for each month. As of June 1, 1971 there were 60 teletypes in operation in 12 different schools as shown in Table 2. Many of these will not be in operation during the summer, but most of them will resume operation in the fall.

Except for MSSD and the schools in the Palo Alto Unified School District, the cost of operation for all the schools listed in Tables 1 and 2 was provided from the grant made to Stanford University by the Bureau for Education of the Handicapped of the United States Office of Education. MSSD and the schools in the Palo Alto Unified School District were able to finance their share of operating expenses.

TABLE 1

Number of Deaf Students Registered for CAI
by Month and by School, 1970-71

(Listed by Month in Which They Joined System)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
Kendall School for the Deaf	100	100	100	100	108	108	110	110	110
Model Secondary School for the Deaf		78	78	78	79	80	80	80	80
California School for the Deaf at Berkeley				337	339	342	332	342	340
Texas School for the Deaf				230	253	248	327	333	333
Palo Alto Unified School District									
Greendell Elementary School				26	28	28	31	31	29
Cubberley High School				9	9	9	9	9	9
Ray Lyman Wilbur Junior High School				16	16	16	16	16	16
San Jose Unified School District									
San Jose High					9	11	11	11	11
Hoover Junior High					8	8	8	8	8
Bachrodt Elementary School					9	16	17	17	16
Hester Elementary School					12	13	13	13	13
Gallaudet College						128	135	6	6
TOTAL	100	178	178	796	870	1007	1089	976	971

TABLE 2

Number of Teletypes per School

	Number of teletypes
California School for the Deaf at Berkeley	15
Gallaudet College**	
Kendall School for the Deaf	12
Model Secondary School for the Deaf	8
Palo Alto Unified School District	
Cubberley High School*	
Greendell Elementary School	3
Ray Lyman Wilbur Junior High School	1
San Jose Unified School District	
Bachrodt Elementary School	2
Hester Elementary School	2
Hoover Junior High School	1
San Jose High School	1
Texas School for the Deaf	15
TOTAL	60

*Cubberley High School students used the three teletypes located at Greendell Elementary School.

**Gallaudet College students used teletypes at MSSD and the Kendall School for the Deaf.

III. CAI Curriculum for Deaf Students

During the 1970-71 school year, deaf students in the 12 participating schools used nine different CAI courses. Operationally each course is identified by a one-letter code, which is given here for future reference.

S - Mathematics Strands Drill-and-Practice
B - Mathematics Blocks Drill-and-Practice
K - Language Arts for the Deaf (old version)
G - Language Arts for the Deaf (new version)
L - Logic and Algebra
W - Computer Programming: BASIC
Q - Computer Programming: AID
E - Basic English
J - Transformational Grammar

The most frequently used of these courses were the mathematics drill-and-practice courses (primarily the newer strands version) and the newer version of the language arts course. Table 3 shows the average number of students run per day on the mathematics drill-and-practice courses from October through June for both mathematics courses, S and B, and the average number of students run per day on the language arts course, G, for February through June.

On January 12, at the school's request, the earlier blocks version of the mathematics program was made available to students at Kendall. The use of the two mathematics programs is reported separately in Table 3, but they have also been summed since the two together represent the total number of deaf students run in both mathematics programs.

From October through January, 25 deaf students from Kendall and MSSD used a preliminary version of the language arts course (the K course). In February, the present G version of the language arts course became available.

The six courses not included in Table 3 (Language Arts for the Deaf, K; Logic and Algebra; Computer Programming: BASIC; Computer Programming: AID; Basic English; Transformational Grammar) were used by fewer deaf students than used the mathematics programs and the G version of the language arts course. Because these six courses were used sporadically, the average number of students run per day does not give a clear indication of use of these courses. Table 4 shows total number of students on each course for the period February-May, 1971.

TABLE 3

Number of Students Who Ran on the Mathematics and Language Arts Courses

October 1970 Through June 1971

		Average Number of Students Run Per Day			
Month	Run days	Strands (S)	Blocks (B)	Total Math	Language Arts (G)
October	19	42		42	
November	14	73		73	
December	17	66		66	
January	19	290	30*	320	
February	19	452	40	492	8
March	23	491	80	571	84
April	21	340	38	378	100
May	20	340	36	376	140
June	14**	178	20	198	61

*Average number of students run per day at Kendall for 14 days in January.

**June 18 was the cut-off date, although a few students at Texas and MSSD continued running after that date.

TABLE 4

Number of Students Run on CAI Programs
February-May 1971

Courses	Feb.	Mar.	Apr.	May
Logic and Algebra	118*	92	113	101
Computer Programming: BASIC	7	10	14	17
Computer Programming: AID	1	1	1	1
Basic English	13	152	152	25
Transformational Grammar			6	11
Totals	139	255	286	155

*This figure includes 35 students who ran on the program from October through January at MSSD.

IV. Description of Mathematics Programs

The development of a drill-and-practice curriculum in elementary mathematics has been a major project of IMSSS since 1964. The mathematics curriculum has undergone yearly revision; sometimes both the strands and blocks drill-and-practice programs have been in use at the same time. During the 1970-71 school year, the majority of deaf students used the strands version of the mathematics program, although some deaf students used the earlier blocks version of the mathematics drill-and-practice program. Part way through the year, special options were put into the strands program to make it more appropriate to the needs of particular groups of deaf students.

1. The Strands Program

During the summer of 1968, a major revision of the mathematics drill-and-practice program was started. The revised program evolved when attention was diverted from a program which could duplicate and expedite classroom procedures for a given grade to a program which could provide the most efficient drill for a given individual from the start of Grade 1 through the end of Grade 7. The questions used to determine the types of problems a child should receive on a drill changed from "What grade is the child in?" and "What is usually taught at that grade level?" to "What concepts has this child mastered?" and "What should this child learn next?"

Attention to the child rather than to the classroom resulted in a reorganization of the drill-and-practice material in elementary-school mathematics into ungraded strands. The student, working on several strands simultaneously, begins at the bottom of a strand and moves upward on each strand as a function of his ability to perform correctly on that strand. Since movement along a strand depends on the student the level of performance on one strand relative to the level of performance on other strands creates a problem set for one student different from the problem set for another student. Thus, unlike the traditional classroom, each student is solving a different set of problems, and each set of problems contains problem types from each strand appropriate to the ability level of the student involved.

The strands program consists of three major elements:

1. A curriculum structure that classifies the problems appropriate for an elementary-school mathematics program;

2. A set of rules for determining the problems to be presented to each student;

3. A set of rules to define the progress of a student through the structure.

The present curriculum structure contains 14 strands. Each strand includes all problem types of a given concept (e.g., fractions, equations) or of a major subtype of a concept (e.g., horizontal addition, vertical multiplication) presented in Grades 1-7. Table 5 shows the 14 strands and the portion of the seven-year curriculum for which they are appropriate.

Within each strand, problems of a homogeneous type (e.g., all horizontal addition problems with a sum between zero and five) are grouped into equivalent classes. Each strand contains either 5 or 10 classes per half year with each class labeled in terms of a grade-placement equivalent. A problem count of problem types occurring in three major elementary-school mathematics texts (Clark, Beatty, Payne, & Spooner, 1966; Eicholz & O'Daffer, 1966; Suppes, 1966) and data collected during the past three years of the drill-and-practice program at Stanford were used to arrange the equivalence classes in an increasing order of difficulty and to insure that new skills (e.g., regrouping in addition) were introduced at the appropriate point in the curriculum.

In addition to the ordering of problems within a strand, we must know how much emphasis is needed on each strand at a given point in the year. To determine this, the curriculum was divided into fourteen parts, each corresponding to half a year. A probability distribution function was developed for the proportion of problems on each strand for each half year. Both the problem count from the three textbooks and the average latency for problem types based on past data were used to develop the curriculum distribution. The final proportion of problems for each half year for each strand are shown in Table 6.

Even though a student is placed below his arithmetic grade level, he is allowed to advance rapidly to a higher level as soon as he shows mastery at the lower levels. For the first ten sessions a student may move through the strands as much as half a grade level at a time. All data on student progress and change in grade level are collected only after the initial ten sessions. This year the deaf students were placed three years below their school grade levels. This policy not only assured that no student would be given problems that were too difficult for him, but also it allowed the student some time to get used to the program before the mathematics became challenging.

2. Modifications of the Strands Program

Most students enjoy and profit from lessons containing a variety of problems. However, teachers at several of the participating schools suggested that certain of their students would benefit from a concentrated exposure to a given concept for a short time. In response to this suggestion, two options were added to the strands program that would allow a student to work on problems from a single strand for a certain period of time.

The first option is called block-structure strands. At the beginning of a lesson, the computer selects from among the strands a student is working

TABLE 5

Mathematics Strands

Strand Number	Abbreviation	Name	Grade-level First Class	Grade-level Last Class
1	NUM	Number concepts	1.0	7.9
2	HAD	Horizontal addition	1.0	3.9
3	HSU	Horizontal subtraction	1.0	3.4
4	VAD	Vertical addition	1.0	5.9
5	VSU	Vertical subtraction	1.5	5.9
6	EQN	Equations	1.5	7.9
7	MEA	Measurement	1.5	7.9
8	HMU	Horizontal multiplication	2.5	5.4
9	LAW	Laws of arithmetic	3.0	7.9
10	VMU	Vertical multiplication	3.5	7.9
11	DIV	Division	3.5	7.9
12	FRA	Fractions	3.5	7.9
13	DEC	Decimals	4.0	7.9
14	NEG	Negative numbers	6.0	7.9

TABLE 6

Curriculum Distribution. Proportion of Problems × 100

	Half year													
Strand	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
num	36	18	16	12	10	04	07	07	10	13	17	10	15	15
had	32	28	26	10	14	08	07	07						
hsu	18	14	16	10	04	04	04							
vad	14	12	12	22	20	06	09	02	04	02	02	02		
vsu		12	12	18	20	08	09	02	04	02	02	02		
eqn		10	10	12	16	11	17	08	08	11	10	10	15	15
mea		06	08	06	06	06	07	07	08	07	07	06	05	05
hmu				10	06	13	09	06	08	08	08			
law					04	06	05	04	06	06	02	02	08	08
vmu						13	06	14	08	04	04	02	08	08
div						17	09	15	16	06	07	02	14	14
fra						04	04	21	22	29	28	24	10	10
dec							07	06	06	12	09	36	10	10
neg											04	04	15	15

on the one with the lowest grade placement. The student works only on this strand for an entire lesson. The computer keeps a record of his progress, and the level he achieves at the end of the lesson becomes his grade placement on that strand. For the next lesson, the computer again selects the lowest strand, which may be the same strand he worked on during the previous lesson, or a new one. If the student has the same grade placement on two strands, the computer makes a random choice.

The second option, called fixed strands, allows the teacher to select a strand and a grade placement for a student to provide practice on a specific concept. The teacher may restrict the student's work to a small portion of the curriculum (described as a fixed level) or allow the student to move freely up the strand. An assignment to the fixed strands will continue for five consecutive lessons, after which the student automatically returns to the type of program, regular strands or block-structure strands, on which he had previously been working.

For both new options the student works through the curriculum one problem at a time. If he makes an error, after completing a problem, he repeats the previous problem (which he had done correctly) and then repeats the problem on which he erred.

Instructions were sent to all teachers and proctors in the participating schools indicating how to sign a student onto one of the options. In many cases a student only needed a bit of concentrated work on one strand before he was able to continue with the regular strands program. The teachers felt that adding these options made the program beneficial to a greater number of students.

3. The Blocks Program

The earlier blocks version of the mathematics program contains many of the features of the newer strands version, such as immediate feedback, self-pacing and individualized selection of the difficulty level of the problems. However, the blocks program did not break away from the basic model of drill and practice as provided in the traditional classroom. The blocks program presents problems of one concept for a given period and then problems of another concept. Different students may be working on different concepts at the same time, but this occurs only because some students move through the program more rapidly than others.

The teachers at the Kendall School for the Deaf were familiar with the blocks version of the mathematics program because they had used it during the 1968-69 school year. Since the Kendall teachers felt that some of their students needed concentrated work on certain concepts, they requested that both the blocks version and the strands version of the mathematics program be made available to them. After the new options were put into the strands version, however, use of the blocks version greatly decreased.

4. Data Analysis

The strands program includes subroutines for the collection of detailed data at the same time the student interacts with the program. This data base is later used for many different analyses of individual performances. The data are also summarized to produce individual and group statistics, and they also provide important information in the development of learning models, such as the automaton models discussed in Section VI.

Various report programs, which give information both to the teachers at the participating schools and to the Stanford research staff, are run at regular intervals (daily, biweekly, monthly, annually). Analyses of these reports present a precise internal measure of individual progress, as well as valuable information about the curriculum and its effects upon the students as a group. The daily report program, for example, shows the progress of individual students in each class, including their current grade placement in each strand, their average grade placement and the standardized rate of change. A typical daily report for one class is shown in Figure 1.

Figure 2 shows the number of deaf students in each of the strands of the mathematics program near the end of the 1970-71 school year. This information was taken from the biweekly report of June 11.

The rate of progress of individual students is measured by a number called the "standardized rate of change." The change in grade placement for each student after a certain number of sessions at the terminal is standardized to the change in grade placement he would have made in 12 sessions. For example, if a student changes .07 of a grade level in six sessions, his standardized rate of change is .14 because he would have changed .14 of a grade level in 12 sessions. Expected number of sessions for a year at the terminal is 120. Since 12 is one-tenth of 120, the student who works at a standardized rate of change of .10 for the expected 120 days will progress one grade level in one school year. A student whose standardized change is greater than .10 will complete a year's curriculum in less than a school year, and the student whose standardized rate of change is less than .10 will complete less than one year's curriculum in a school year. If the number representing the standardized change is negative, the student's position at the end of the two-week period was lower than it was at the beginning of the period. The standardized rate of change is calculated biweekly and is shown on the daily report in the column labeled CHG. The number does not indicate the change in grade placement of that student during the preceding two weeks, but rather the amount of change he would have made had he worked 12 sessions. This number allows for the comparison of the rate of progress of students, even if they worked a different number of sessions during that two-week period.

CLASS 230 TEACHER'S NAME DATE
7 STUDENTS SCHOOL NAME GRADE 2

MATH STRANDS REPORT

AVG	CHG	SES	PBS													
			NUM	HAD	HSU	VAD	VSU	EQN	MEA	HMU	LAW	VMU	DIV	FRA	DEC	NEG
20	WW	12:	302	+	220	STUDENT NAME										
			20	20	20	20	20	20	20							
60	NA	18	273	+	780	STUDENT NAME										
			59					60	60		60	60	60T	69	60	60
17	Y	21	503		289	STUDENT NAME										
			17	16	17	16	17	15	16							
29	NA	95:	352'	+	403	STUDENT NAME										
			30	30	30	30	29	30	30	30	30					
16	NA	1	125		340	STUDENT NAME										
			16	16	16	16	15	17	16							
10	NA	1:	3	+	230	STUDENT NAME										
			10	10	10	10										
46	X	16	338	+	682	STUDENT NAME										
			46			49	48	46	45	47	45	46	45T	47	45	
CLASS MEANS																
27		23	722													
			28	18	18	23	32	39	38	38	45	53		53	52	60
HIGHEST																
60		95	352													
			59	30	30	49	48	60	60	47	60	60	45T	59	60	60
LOWEST																
10		1	3													
			10	10	10	10	20	20	20	30	30	46		47	45	60

Fig. 1. Mathematics strands program - daily report.

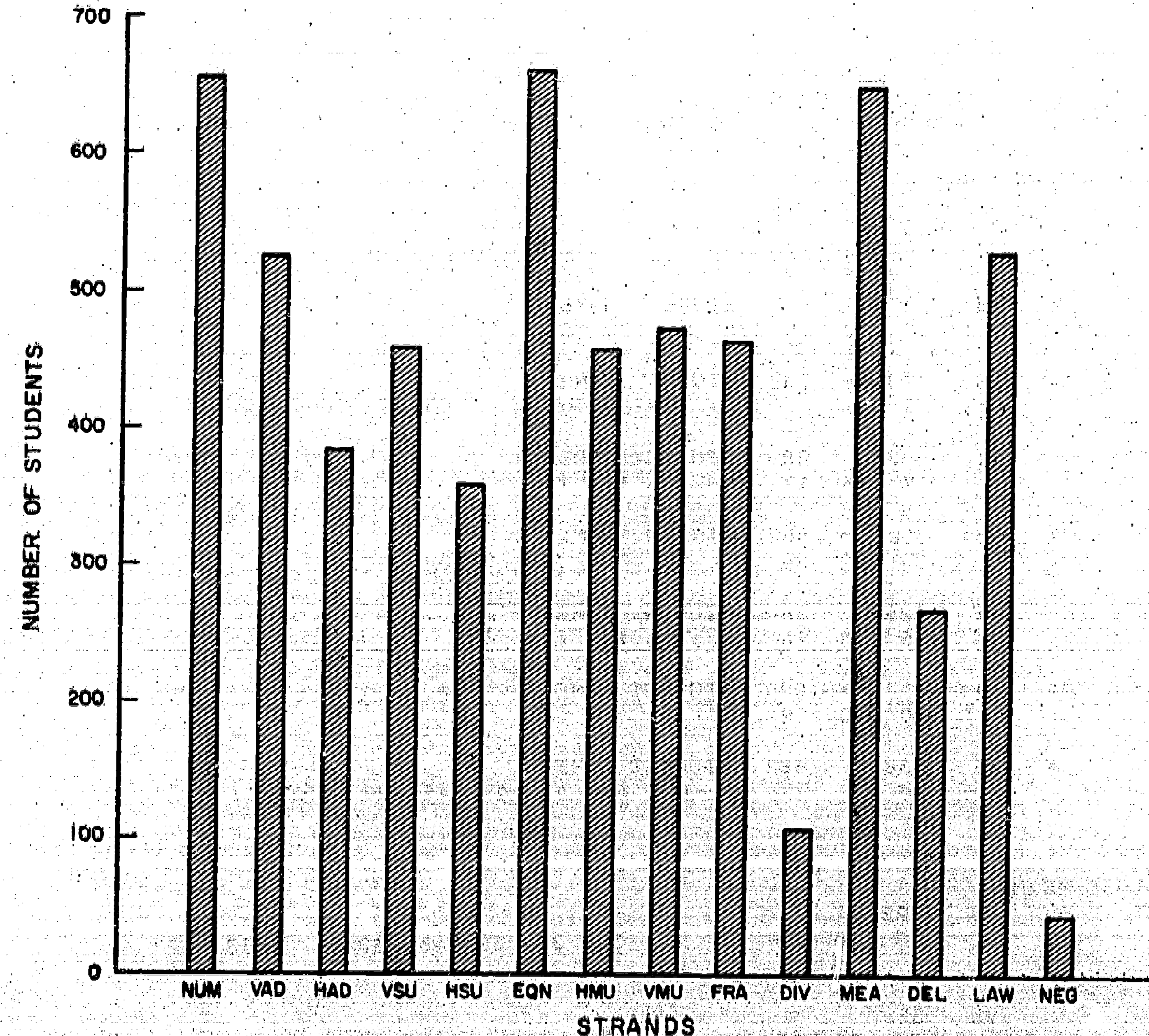

Fig. 2. Number of deaf students in each strand as of June 11, 1971. For strand names see Table 5.

Figure 3 shows the average standardized rate of change for deaf students from February through May. In February there were 419 deaf students on the strands course; their average standardized change was .39. In March there were 487 deaf students on the strands course; their average standardized change was .19. In April there were 480 students and their average change was .13. In May there were 405 students and their average standardized change was .12.

It is not surprising that the standardized rate of change should have decreased from February to June. A majority of the students did not begin the program until February, and since they started far below their tested grade level in mathematics, they would be expected to move more rapidly at the beginning of the program and slower as they approached their actual level of competence. It is possible that the introduction of the new blocks and fixed strands options in the mathematics program reduced the average standardized rate of change since a student who was put on one of these alternate formats might not have progressed as rapidly as he would on the regular strands course. However, even by the end of May, the deaf students were still progressing at a rate of change that would enable them to complete a year's curriculum in less than a school year if they worked at least 120 sessions during the year.

In considering the rate of change of deaf students in the mathematics course, it is important to remember that the strands course used by the deaf students is the same as that used by about 1,800 hearing students. The standardized change is computed separately for the deaf students as a group, but the method used is the same. The average absolute grade-level change for deaf students (taking into consideration the exact number of days they were on the course, from the beginning of February to the end of May) was 1.35.

Even if we assume that the student may not have worked his way up to his actual grade level during the first ten days, this is surprising progress, since deaf students usually progress half a grade each year. In only four months these students advanced more than one grade level. We have not yet been able to look at any external evaluation of progress; however, we do plan to make a comparison of internal and external measures of progress on the mathematics course next year.

V. Description of the Language Arts Programs

While a great effort has been put into the installation of equipment, teacher training and the daily operation of the system this first year, the major emphasis has been the development of language arts programs for the deaf. In this part of the project we have been substantially aided by teachers and administrators in the participating schools, and also by a consulting board comprised of educators and researchers in deaf education.

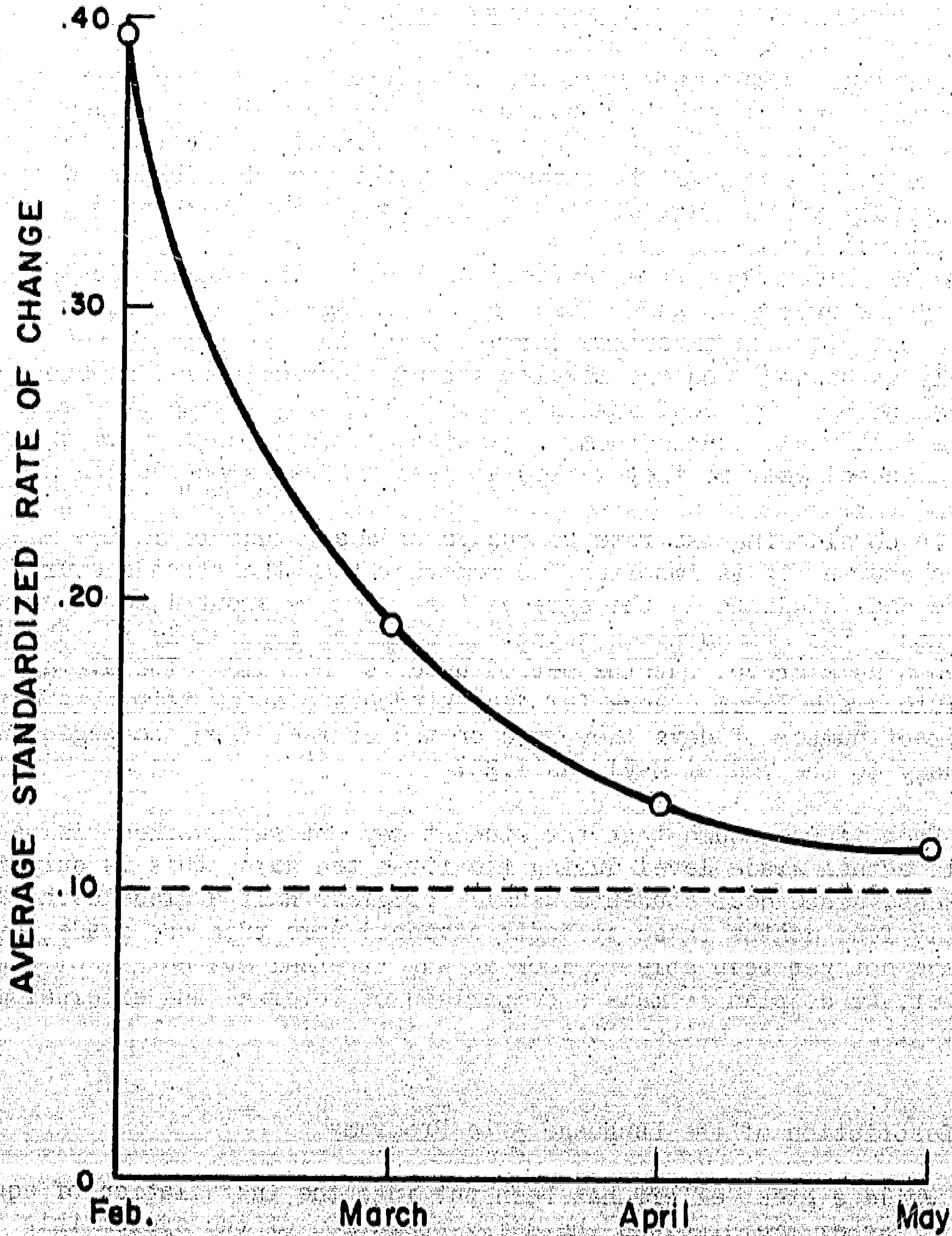

Fig. 3. Progress of deaf students in the mathematics strands program from February through May, 1971.

Three very different programs in the field of language arts are being developed simultaneously. Two of these are still in the experimental stage. The first is a communicative device which is essentially a tool for motivating students in the development of expressive writing skills (T program); at the same time this program will provide a substantial data base for basic research in developmental psycholinguistics. The second is a highly structured, rigorous program in transformational grammar (J program). The third program, Language Arts for the Deaf (G course) is a drill-and-practice course in English grammar which is already being used extensively in the participating schools.

1. The Talk Program

The conversation program is still being developed and will be ready for use in September, 1971. From a student's point of view, the program will act like a telephone operator; it will ask the student what number he wants to call and will connect him with any teletype tied into the Stanford computer system that is not involved in transmitting a drill program. The student is then free to converse about any subject he chooses.

The student's name is inserted automatically by the program once he has initially identified himself. The printed conversation is formatted like a script.

CHRIS: HELLO, ARE YOU FINE TODAY?

LARRY: YES, I AM FINE. THANK YOU.
HOW IS YOUR SCHOOL?

CHRIS: WE HAVE SUMMER VACATION.
WHAT WILL YOU DO AT VACATION?

LARRY: I HAVE FUN.

Although the subjects of conversation will not be restricted in any way, the conversation will be continuously recorded so that substantial data may be collected on the spontaneous conversational language of deaf students.

The program provides deaf students with a means for using written English for direct communication and provides an opportunity for language practice in an environment that is intrinsically rewarding to the students. Preliminary testing of this program with students has already been completed in several schools. The students were eager to use the program and had no difficulty in learning to operate it.

As students converse with one another, the entire conversation is recorded for later analysis (users of the program are warned that their conversations are being recorded). This corpus will be used in future studies in which techniques of linguistic analysis will be applied as exemplified in previous studies in linguistics undertaken by Institute staff (Gammon, 1970; Suppes, 1970, 1971).

2. The Transformational Grammar Program

The transformational grammar program is being developed in association with MSSD, which has provided funding for the salaries of a curriculum coordinator in Washington, D.C., a curriculum writer and a part-time computer programmer at Stanford.

The transformational grammar program is still experimental at this time; even though it was used in spring 1971 by a small number of students at Kendall and at MSSD, it will not be ready for more general use for another year. The aim of this program is to provide instruction in transformational grammar in a rigorous way, related more to the teaching of symbolic logic or axiomatic algebra than to traditional methods for teaching grammar. The rationale for this course and a description of the work to date will be forthcoming as a technical report within the next few months.

Basically, the computer is programmed to produce grammatically correct English sentences, acting on commands given it by the student. The student is free to give any rules he wishes, choosing whatever sentence patterns he likes, whatever kinds of noun phrases and verb phrases he desires, and whatever transformations he would like the computer to use. As long as the rules requested by the student will produce grammatically acceptable sentences, the computer will accept them and will act on them to produce the sentence the student has specified. Here is an example from one of the yearly lessons, beginning with these instructions to the student.

YOU TYPE	COMPUTER PRINTS
	(NP) TASTES GOOD.
/PL	(NP) TASTE GOOD.
/NP3	(D)(N) TASTE GOOD.
D.THE	THE (N) TASTE GOOD.
N.LUNCH	THE LUNCHES TASTE GOOD.

The student then executes the steps.

	(NP) TASTES GOOD.
RULE */PL	
	(NP) TASTE GOOD.
RULE */NP3	
	(D)(N) TASTE GOOD.
RULE *D.THE	
	THE (N) TASTE GOOD.
RULE *N.LUNCH	
	THE LUNCHES TASTE GOOD.

The exercise starts with a brief review for the student, listing the rules he must use to transform the incomplete sentence

(NP) TASTES GOOD.

to the complete sentence

THE LUNCHES TASTE GOOD.

Almost all of the typing, including the various stages of sentence construction is done by the computer. The student is required to type only the mnemonic-rule names immediately following the word RULE. The generation of the sentence itself is done by the computer. In this example, the student started with a plural transformation, using the rule /PL. Rule /PL calls for a pluralization of the subject of the sentence, so the (NP), i.e., noun phrase, which is the subject, is then internally tagged as plural. The only visible effect of the /PL rule at this first stage is the change of the verb from "tastes" to "taste" for subject-verb agreement.

Next the student gave the rule /NP3, calling for the third type of noun phrase, the determiner-noun type, here symbolized as (D)(N). The numbering of noun-phrase types is arbitrary, and the student was provided with a list of rules and their meanings so that he could refer to the list if he needed to refresh his memory; the student, however, will most likely have memorized at least the first three noun-phrase types by this point in the curriculum.

The student was now faced with the sentence form

(D)(N) TASTE GOOD.

which becomes a finished surface-level sentence after substitution of actual words for the symbols (D) and (N). This substitution may be made in any order; in the above example, the student worked from left to right, substituting first for the determiner and then for the noun. The student could have substituted any suitable determiner and noun, and they would have been accepted; for example, he might have produced

AN APPLE

or

MOST ORANGES

and the program would have generated the sentence he requested whether or not it fulfilled the requirements of this particular exercise.

Notice that the student made a noun substitution by typing the singular form of the noun and not the plural that he actually wanted. In all cases, the student must know, and use, the simple or root form of a word; the inflection will be made by the program.

We are now working with a small dictionary of about six hundred words, which will be extended to several thousand words soon. Although this program is concerned with grammar rather than with semantics, a

substantial part of the research will eventually lead to the development of a conversational program that will produce meaningful and grammatically correct English sentences.

3. Language Arts for the Deaf Course

The Language Arts for the Deaf program is a drill and practice program including grammar and usage. This program is the largest and best developed of the three language programs. The detailed design and development of this course began in July 1970 and students started using the course in February 1971. The course consists of a set of lessons, each of which contains between 20 and 30 exercises. Each lesson is preceded by a short pretest, so that the more gifted or more knowledgeable students may take only six or seven exercises in a lesson while students who need more assistance may take up to 30 exercises. Over 100 of these lessons are written and programmed and at least 100 more will be produced in the next year, making a total of over 4,000 exercises.

The course is designed for deaf students of junior high school age. Most of the students are between 12 and 16 and read at about the 3.0 reading level as measured by standardized tests such as the Stanford Achievement Test or the Metropolitan Test. In order to accommodate children with a low reading level, we have carefully controlled the vocabulary and sentence structure used in the instructions and exercises; the reading level is held to about the third-grade, while the vocabulary and complexity of the sentences are held to even lower levels.

A language program, designed specifically for the deaf, is necessarily much different from a language program for the hearing. Both deaf and hearing children need to learn how to read and write, how to spell and punctuate correctly, how to use the dictionary, how to express themselves fluently and grammatically. But one basic, striking difference between the needs of deaf children and hearing children is that deaf children must learn the significance and structure of the English language itself.

For a hearing child in an ordinary public school classroom, the reading program divides itself into two primary components: the development of decoding skills, and language development. Decoding skills enable the child to translate, word by word, the printed symbols to the spoken word and include the ability not only to apply grapheme-phoneme correspondences for phonetically represented words, but also to recognize, on sight, a large number of irregular (nonphonetic) common words. For the child who speaks English fluently before beginning to read, the word-by-word decoding skills are the most important. For example, if a hearing child can pronounce each individual word in a sentence, he can understand the meaning of the sentence. Occasionally a child may also need additional language development, i.e., vocabulary development; the child who is in some way culturally or socially deprived may need not only vocabulary development, but he may also need help in the more basic skills, such as the correct use of English inflections. It is important to note that

the language-deprived hearing child has usually internalized the role of inflection and syntax before he begins his formal education, and that the difference between his language and the accepted idioms may indicate nothing more than slight cultural variations.

The deaf child, on the other hand, particularly the prelingually deaf, has not internalized the basic structure of English before he starts school. He does not understand the use of syntax or inflection, nor does he have a basic vocabulary. The child who is born deaf or who becomes deaf before he acquires a language, and who is thus deprived of the normal exposure and feedback that produce language in the hearing child, may never assimilate the basic principles of language that the hearing child acquires at an early age. Because there is little or no inner language into which to translate written symbols, the deaf child cannot be taught to read from decoding skills alone.

These language deficiencies of the deaf child have been taken into consideration in the development of the Language Arts for the Deaf Course. The course has been designed to stress the deep structure of the English grammar, with particular emphasis on the roles of syntax and inflection, and on the meanings of the function words.

The following are a few of the topics that will be covered in lessons dealing with the structure of the simple noun phrase.

<u>The simple noun phrase</u>

Determiner-noun agreement
Formation of plural nouns
Syntax of adjective strings
Number, case and gender of pronouns
Double nouns and their inflections
Distinction between mass and count nouns
Determiners used with mass nouns
Partitives

Verb phrases will also be covered in considerable detail, as will the relationships, both syntactical and inflectional, between noun phrases and verb phrases.

<u>Verb phrases</u>

Subject-verb agreement
Tense, past and present
Formation of present and past progressive
Use of modals
Perfect aspect
Separable and non-separable double verbs

Under the general heading of modifiers are adverbs, adjectives and prepositional phrases used to modify nouns or verbs.

Modifiers

Classification and position of adverbs
Relation between time and tense
Syntax of prepositional phrases
Idiomatic use of prepositions
Intensifiers
Comparative and superlative adjectives
Subordinate clauses

Broader aspects of the relations between component phrases are considered in the sentence patterns and transformations topic.

Sentence patterns and transformations

Direct objects
Indirect objects
Double direct objects
Negation
Coordination
The passive construction
Question forms and question tags
Question responses

Lessons in the language arts course are designed to specific behavioral objectives related to the kind of topics listed above. The course will contain several hundred lessons; of these, over 100 lessons are now completed (see Appendix 1 for list of completed lessons).

The course begins with an introductory lesson and a set of 25 lessons on the language of directions.

INTRO	Introduction
DIR 1	first, second, third word
DIR 2	after
DIR 3	first, second, third, fourth, last word
DIR 4	first, second, last letter
DIR 5	first, last letter
.	
.	
.	
DIR 22	under
DIR 23	below, under
DIR 24	above
DIR 25	above, below, under

The introductory lesson teaches the student how to respond by typing his answers, how to indicate that his response is complete, and how to type special characters, such as a space between two words. Some exercises emphasize the difference between similar characters, such as the "O" and the zero, or the letter "I" and the digit "1." The first lesson also contains exercises introducing special response modes, such as numbered multiple choices, that will be used extensively later in the course.

The 25 lessons on directions are aimed at getting the student to read and respond to precisely worded directions of the types that he will encounter in later lessons. These directions might be something like "Which is the first word in this sentence?" or "Type the third word." The specific vocabulary includes the ordinal adjectives, "first," "second," "third," and "last"; the prepositions "after," "before," "under," "below," and "above"; and the sentence connector "and." The syntax of the directions varies to include both imperatives (Type the number below 5.) and interrogatives (Which number is below 5?). In the prepositional phrases, the object of the preposition may be a direct reference (Type the number under the word "baby.") or it may be an indirect reference (Type the number under the third word).

We have found that these lessons on the language of directions have been well received by both teachers and students, and preliminary evidence indicates substantial learning. The different amounts of time needed to go through these lessons is a convincing indication of the amount of individualization of instruction allowed by the course; some students worked through all 25 directions lessons in two days, while others needed up to two weeks.

After the directions lessons, the main body of the course begins with a set of lessons on the structure of the noun phrase.

NAA	common nouns introduced
NAB	common nouns continued
DAA	determiners introduced (a, an, the)
MAA	mixed drill: identification of nouns and determiners
MAB	mixed drill: nouns and determiners
MAC	mixed drill: nouns and determiners
LAA	vowels introduced
DAB	determiners: use of "a" and "an"

Identification of nouns and determiners is introduced and then the correct use of "a" and "an" is covered. In the following lessons other frequently used determiners such as "some," "every," and "no" are introduced one at a time. Then they are compared and contrasted.

Here is a sequence of lessons a little further along in the course.

NAC plural nouns introduced

NAD plural nouns (-s)

NAE plural nouns (-s, -es)

NAF plural nouns (-ies)

NAG plural nouns, all types

NAH plural nouns, irregular

DAD determiner-noun agreement in number (one, two)

MAE determiner-noun agreement (some, every, no)

Drills on forming regular plural nouns are presented, followed by a review of irregular plurals such as "man-men," "child-children." The concept of determiner-noun agreement of number is introduced in lesson DAD using the cardinals "one," "two," "three," etc. In lesson MAE the concept of agreement of number is extended to include the use of "some" with plural-count nouns and the use of "every" and "no" with singular count nouns.

The lessons continue in similar steps, gradually bringing in other concepts such as position of adjectives within a noun phrase; use of other determiners; distinction between mass and count nouns and appropriate use of determiners; pronouns, and the correct use of number, case, and gender; and work on verbs, auxiliaries, tenses.

Throughout the course, the contribution of structure to meaning is stressed. Exercises are given in the form of complete sentences, and the semantic implication of each grammatical rule is made soon after the rule is introduced.

4. Course Usage

The only one of the three language courses that has been used extensively this year is the grammar course, Language Arts for the Deaf. Although this course provides the option of using the lessons in any order, most teachers chose to follow the order given in the outline. Figure 4 shows the number of students who have done each of the first one hundred lessons. See Appendix 1 for the name of each numbered lesson and a brief description of the lesson.

5. Data Analysis

All three of the language arts programs described in Part A include data collection routines; the collected data are being stored for later analysis. Some data analysis programs have already been written for the Language Arts for the Deaf course. The most important of these is an item analysis program. From the G version of the course, an item analysis that reports the number of students who did each exercise and the number of correct first responses was completed for the first 108 lessons. A

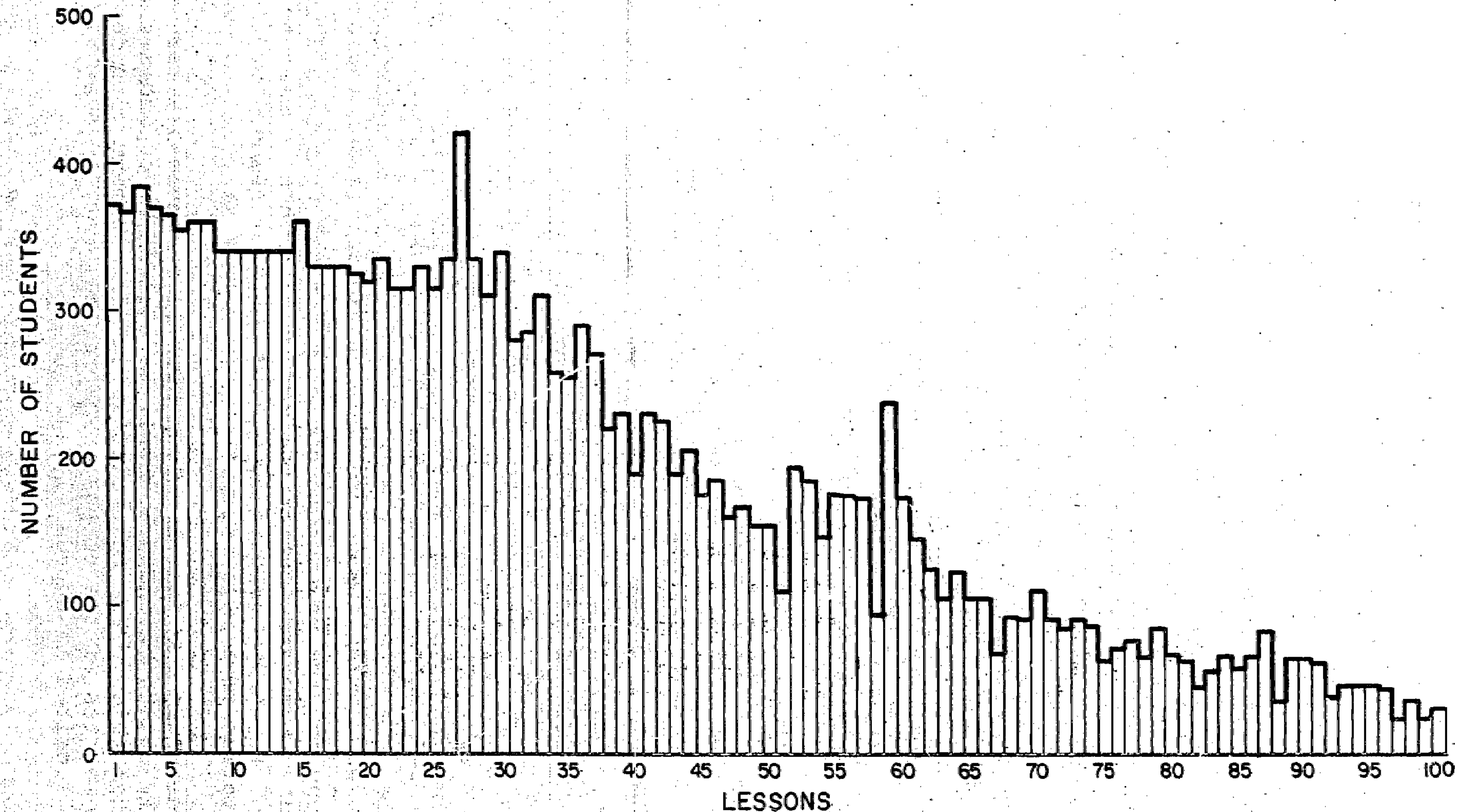

Fig. 4. Number of students on the Language Arts for the Deaf course during spring 1971. See outline in Appendix 1 for lesson descriptions.

second item analysis program which will provide more specific information about incorrect responses is now being written.

No analyses of the data collected by either the transformational grammar program or the conversation program have yet been made. However, a theoretical structure has been developed for the analysis of the data obtained by the conversation program. Since this work will probably be one of the most significant pieces of basic research performed in the course of this project, a brief discussion of the theory is warranted here.

Basically, the intention is to develop a rigorous description, both grammatic and semantic, of the spontaneous language of the deaf, using as a corpus the data collected by the conversation program. Although an adequate grammar does not exist for English (or any other natural language), members of the IMSSS staff have been developing precisely formulated models for selected subsets of English. Context-free generative grammars have been developed for a corpus selected from first-grade readers (Gammon, 1970) and for a corpus of young children's speech (Suppes, 1970). The grammars that have been written are probabilistic with parameters for the probability of application of each generative rule. Such a grammar might look something like this.

Production Rule	Probability
$S \rightarrow NP + V$	a_1
$S \rightarrow NP + V + NP$	$a_2 = 1-a_1$
$NP \rightarrow Pro$	b_1
$NP \rightarrow N$	b_2
$NP \rightarrow Det + N$	b_3
$NP \rightarrow Det + Adj + N$	$b_4 = 1-(b_1+b_2+b_3)$

In particular, one would express the probability of each grammatical type that occurred in the corpus in terms of the above parameters. For example, the type Pro + V + Det + N would have a theoretical probability of $a_2 b_1 b_3$. Using the theoretical probabilities and the observed type frequencies, the parameters can be estimated by standard maximum-likelihood methods. Standard statistical methods can then be used to measure goodness of fit and thus determine which of two grammars provides the best description of a given corpus.

Although the example given here is a simple grammar, the method clearly can be extended to apply to context-free grammars with transformational rules. The next step is the development of a description of the semantics of the corpus. Theoretical work in that direction has been described in Suppes (1971).

VI. Other Work in Progress

1. Automaton Models

The research staff of the Institute is just completing a study of the application of probabilistic automaton models to hearing students' performance on the algorithms of addition, subtraction and multiplication. Reasonably good fits are being obtained in these models with the introduction of only a small number of error parameters. Typical parameters are those for remembering a carry or borrow.

A comparison of the values of these parameters for normal and deaf students will be of considerable interest. We hope by early fall to have similar data with estimations of the parameters for deaf students. At the present time it is too early to speculate whether any significant differences will appear. It is true that a superficial scan of the data does not indicate any systematic differences in performance. If so, this stands in sharp contrast to systematic data on the language behavior of deaf students.

The theoretical framework for the probabilistic automaton models is found in Suppes (1969). The data analysis of performance of normal students is just being completed as a technical report by Alex Cannara and Suppes, and will be available sometime this fall.

2. Language Test

During the spring of 1971, work began on a test that would measure the progress of deaf students in the Language Arts course and at the same time measure their ability in the curriculum areas covered by this course. Most teachers of the deaf agree that none of the available standardized tests are suitable for measuring the language ability of deaf students. Certainly none of them cover exactly the topics included in this particular course.

A preliminary version of the language test was written in May 1971. This version was divided into eight subtests, which cover the following topics: directions, parts of speech, noun phrases and double verbs, determiners, singular and plural noun forms, pronouns, subjects and predicates, and adjective transforms. These main topics are covered in the first 107 lessons of the Language Arts for the Deaf Course. A copy of this preliminary version of the test is included as Appendix 2.

At the end of May the test was given to 60 junior high and senior high school students at the California School for the Deaf in Berkeley. The test was not designed as a speed test, so each class was given enough time for all of the students to finish each subtest before going on to the next. The class was first asked to work through the example problems for the subtest. Then when these had been checked and any questions about directions had been answered, the students were allowed to complete the

subtest. No class took more than 10 minutes to complete any of the subtests, and most of them took less than 5 minutes.

Although we have no definite measures of reliability or validity for this preliminary version of the test, it is still interesting to look at the general performance of the group that took the test. Most of the test items were passed by a large majority of the students. Only about 12 percent of the total responses were incorrect. Two of the classes that took the test (a ninth-grade class and a tenth-grade class) had used the CAI grammar drill-and-practice course. About 8 percent of their total responses were incorrect. Another factor worth noting is that there was little variation among the grades, and there was certainly no obvious improvement in scores as the grade level increased. This corresponds with observations that have been made about the performance of deaf students on other tests (Gentile, 1969).

During the summer a reliability index will be determined for the test and some attempt will be made to establish its validity. The test will be modified, based on this information as well as on suggestions made by teachers at the Berkeley school. The test will also be expanded to include topics from the first two hundred lessons. Two versions of the modified form of the test will be prepared, so that the students can be given both a pretest and a posttest. Although the test will probably be modified again during the summer of 1972, the results of the testing during the 1971-72 school year should give a fairly accurate measure of both individual and group progress on the Language Arts for the Deaf Course.

VII. Dissemination of Information

1. Technical Reports

Friend, Jamesine. Computer-assisted instruction for the deaf at Stanford University. December 1, 1970, Stanford University, Institute for Mathematical Studies in the Social Sciences.

Friend, Jamesine. INSTRUCT coders' manual. Technical Report No. 172, May 1, 1971, Stanford University, Institute for Mathematical Studies in the Social Sciences.

(Copies of these technical reports have already been submitted to the Bureau of Education for the Handicapped of the United States Office of Education.)

2. News Articles

Several articles about the Stanford CAI for the deaf project have appeared in newspapers and news bulletins. At the beginning of the school year there were articles in both the San Jose Mercury News and the Palo Alto Times. Three articles appeared in the "Lone Star," a newspaper published by the Texas School for the Deaf. An article was

also printed in "Behavior Today," the Human Sciences Newsletter. The following articles were published in major magazines of the deaf community.

Burdett, R. Interview with Ron Burdett at Stanford. The Deaf Californian, 1971, 2, 7.

Jacobs, L. The computer assisted program for the deaf. The Deaf American, 1971, 23, 3-5.

Leslie, J. A new teacher's aid: The computer. The California News, 1971, 86, 10-11.

3. Lectures and Demonstrations

On October 19, 1970 a conference was held by IMSSS at Stanford for the consulting board of the Stanford CAI for the Deaf Project. The conference was attended by the following consultants:

Dr. Richard Brill, Superintendent, California School for the Deaf at Riverside, California.

Josephine Carr, Program Director, The Deaf, Oregon College of Education, Monmouth, Oregon.

Ralph Neesam, Supervising Teacher, High School, California School for the Deaf at Berkeley.

Dr. Robert Panara, Chairman, English Department, National Technical Institute for the Deaf, Rochester, New York.

David Spidel, Assistant Director, Project LIFE, Washington, D.C.

Dr. Alice Streng, College of Education, University of Cincinnati, Cincinnati, Ohio.

Hugh Summers, Assistant Director, Southwest Regional Media Center for the Deaf, Las Cruces, New Mexico.

The following members of the IMSSS staff spoke at the conference: Richard Atkinson, Jamesine Friend, Max Jerman, Patrick Suppes, and Mona White.

Several other lectures were given in connection with this project.

Friend, Jamesine. The role of computer-assisted instruction in the education of the deaf. Lecture presented at the Council for Exceptional Children Conference on Instructional Technology in Special Education, San Antonio, Texas, December 1-5, 1970.

Friend, Jamesine. Participant, Postgraduate Symposium on Hearing and Speech, Department of Postgraduate Medical Education, University of Kansas, Kansas City, Kansas, February 18, 19, 1971.

Friend, Jamesine. The potential of computer-assisted instruction in deaf education. Lecture and demonstration presented to a meeting of the Deaf Adults With Needs (DAWN) project at the California School for the Deaf, Berkeley, California, February 27, 1971.

Friend, Jamesine. The Stanford computer-assisted instruction system. A lecture and demonstration presented to the Coordinating Committee Meeting of the County-wide Day Schools for the Deaf, Texas School for the Deaf, Austin, Texas, March 18 and 19, 1971.

Friend, Jamesine. The Stanford computer-assisted instruction for the deaf project. A lecture and demonstration presented to a meeting of the California Council for Exceptional Children, California School for the Deaf, Berkeley, California, April 14, 1971.

Friend, Jamesine. Computer-assisted instruction for the deaf at Stanford University. A lecture and demonstration presented to a meeting of the National Advisory Committee on Education of the Deaf, California School for the Deaf, Berkeley, California, May 14, 1971.

Friend, Jamesine. The Stanford programs in computer-assisted instruction. A lecture and demonstration presented to a workshop on Improved Vocational, Technical and Academic Opportunities for Deaf Persons, Seattle Community College, Seattle, Washington, June 2, 1971.

Friend, Jamesine. Computer-assisted instruction in language. A lecture and demonstration presented to the 45th Convention of American Instructors of the Deaf, Little Rock, Arkansas, June 27 to July 1, 1971. This lecture will be published in the forthcoming Proceedings of the conference.

Suppes, Patrick. An introduction to computer-assisted instruction for deaf students. A lecture presented to the Symposium on Research and Utilization of Educational Media for the Deaf, Midwest Regional Media Center, University of Nebraska, Lincoln, Nebraska, March 22-24, 1971. This lecture will be published in the forthcoming report on the symposium.

REFERENCES

Clark, C. H., Beatty, L. S., Payne, J. N., & Spooner, G. A. Elementary mathematics, grades 1-6. New York: Harcourt, Brace & World, 1966.

Eicholz, R. E., & O'Daffer, P. G. Elementary school mathematics, grades 1-6. Palo Alto, California: Addison-Wesley, 1968.

Gammon, E. A syntactical analysis of some first-grade readers. Technical Report No. 155, June 22, 1970, Stanford University, Institute for Mathematical Studies in the Social Sciences.

Gentile, A. Academic achievement test performance of hearing impaired students. Publication No. Series D, No. 1, September 1969, Gallaudet College, Office of Demographic Studies.

Suppes, P. Sets and numbers, grades 1-6. New York: Singer, 1966.

Suppes, P. Stimulus-response theory of finite automata. Journal of Mathematical Psychology, 1969, 6, 327-355.

Suppes, P. Probabilistic grammars for natural languages. Synthese, 1970, 22, 95-116.

Suppes, P. Semantics of context-free fragments of natural languages. Technical Report 171, March 30, 1971, Stanford University, Institute for Mathematical Studies in the Social Sciences.

APPENDIX 1

Outline of Lessons in Language Arts for the Deaf

INTRO Introduction

DIR Vocabulary of Directions

DIR1	first, second, third word
DIR2	after
DIR3	first, second, third, fourth, last word
DIR4	first, second, last letter
DIR5	first, last letter
DIR6	after; letters and words
DIR7	before; words
DIR8	before; letters
DIR9	after, before; letters
DIR10	after, before; words
DIR11	after the first; letters
DIR12	before the last; letters
DIR13	letters: first, after the first, last, before the last
DIR14	letters: first, second, third, fourth, last, after the first, before the last
DIR15	first two letters
DIR16	first two letters
DIR17	first two, last two letters
DIR18	and; first, second, third, last letters
DIR19	more than one word, spaces between words
DIR20	and; first, second, third, fourth, last, before the last words
DIR21	below
DIR22	under
DIR23	below, under
DIR24	above
DIR25	above, below, under

NAA common nouns, introduction

NAB common nouns, continued

DAA determiners introduced (a, an, the)

MAA mixed drill: identification of nouns and determiners

MAB mixed drill: nouns and determiners

MAC mixed drill: nouns and determiners

LAA vowels introduced

DAB determiners: use of "a" and "an"

MAD identification of nouns and determiners

NPAA introduction of noun phrase (det. noun)

NPAB	noun phrase (single noun)
DAC	cardinals as determiners (one, two, three)
NAC	plural nouns introduced
NAD	plural nouns (-s)
NAE	plural nouns (-s, -es)
NAF	plural nouns (-ies)
NAG	plural nouns, all types
NAH	plural nouns, irregular
DAD	determiner-noun agreement in number (one, two)
MAE	determiner-noun agreement (some, every, no)
NPAC	review noun phrases (including new determiners)
DAE	determiner-noun agreement (a, some)
DAF	review determiners (cardinals)
DAG	review determiners (a, an)
DAH	determiner-noun agreement (a, an, some)
VAA	verbs introduced (one-word verbs)
VAB	one-word verbs, continued
MAF	mixed review: verbs, determiners, nouns
VAC	two-word verbs introduced (progressive form)
VAD	review one- and two-word verbs
MAG	mixed: identify noun phrases and verbs
VAE	modals introduced (can, may, might, must, should, would, could)
AJAA	adjectives introduced (color)
AJAB	adjectives (shape and size)
AJAC	adjectives (identify two in sentence)
MAH	mixed: nouns, adjectives, determiners, verbs
MAI	mixed: nouns, adjectives, determiners, verbs
NPAD	identify noun phrases with adjectives
NPAE	noun phrases with adjectives
NPAF	first and second noun phrases
AJAD	predicate adjectives introduced
MAJ	mixed review: noun phrases and verbs
MAK	mixed review: adjectives, noun phrases, verbs
NPAG	nominative noun phrases ("who," "what" questions)

NPAH	objective noun phrases
NPAI	noun phrases, subject and object questions
AJAE	adjective transform introduced (subject noun phrase)
AJAF	adjective transform (position of adjective)
AJAG	adjective transform (object noun phrase)
AJAH	adjective transform (position of adjective)
SAA	sentences: subject and predicate introduced
SAB	subject and predicate, continued
PNAA	pronouns introduced (he, she, it, they)
PNAB	pronouns introduced (I, you, we)
PNAC	pronouns introduced (me, him, her, it, us, them)
NPAJ	pronouns as noun phrases
SAC	subject and predicate (pronoun subjects)
PNAD	pronoun-antecedent agreement (he, she)
PNAE	pronoun-antecedent agreement (he, she, it)
NPAK	review singular and plural noun phrases
PNAF	pronoun-antecedent agreement (it, they)
PNAG	pronoun-antecedent agreement (he, she, it, they)
MAL	mixed review: identify nouns and pronouns
MAM	mixed review: determiners, adjectives, verbs, nouns, pronouns
PNAH	pronoun-antecedent agreement (her, him)
PNAI	pronoun-antecedent agreement (her, him, it)
PNAJ	pronoun-antecedent agreement (her, him, it, them)
SAD	review subject and predicate
PNAK	pronoun-antecedent agreement (she, her, he, him)
PNAL	pronoun-antecedent agreement (they, them)
NPAL	singular and plural noun phrases, including pronouns
DAI	determiner introduced (all)
DAJ	determiner-noun agreement (all, every)
DAK	double determiners
NPAM	singular and plural noun phrases
NAI	review irregular plural nouns
DAL	review determiner number (a, an, some, cardinals)

NAJ	plural nouns with same form as singular
NAK	mixed review of plural nouns
DAM	review singular and plural determiners
DAN	singular and plural noun phrases using "some" and "every"

APPENDIX 2

IMSSS Language Test (Preliminary Version)

Subtest 1 - Directions

Sample Questions
A) Circle the third word. The rain washed my car for me.
B) The class took a trip to the cookie factory. 1 2 3 4 5 6 7 8 9 Write the number under "cookie": ___

1) Circle the first word.

People are funny sometimes.

2) I see two nests in the oak tree.
1 2 3 4 5 6 7 8

Write the number under "tree." ____

3) Circle the word before "show."

Last weekend there was a puppet show in the park.

4) Circle the fourth word.

Our friends are painting their house red.

5) Circle the last word.

A baby camel was born in the zoo.

6) Mother and her friend Bill went swimming.
1 2 3 4 5 6 7

Write the number under the word "friend": ____

7) Circle the word after "sleep."

Little babies eat and sleep most of the time.

8) Circle the word before "horse."

My mother rode a horse to school.

Subtest 2 - Identify Parts of Speech

Sample Questions

I see an elephant.
1 2 3 4

A) Write the number under the noun. ____
B) Write the number under the pronoun. ____

Mother thinks it is silly.
1 2 3 4 5

1) Write the number under the pronoun. ____
2) Write the number under the adjective. ____

We saw seeds inside the flower.
1 2 3 4 5 6

3) Write the number under the determiner. ____
4) Write the number under the first noun. ____
5) Write the number under the pronoun. ____

Ron drives a little yellow car.
1 2 3 4 5 6

6) Write the number under the verb. ____
7) Write the number under the first adjective. ____

She picked six lemons from the tree.
1 2 3 4 5 6 7

8) Write the number under the second noun. ____
9) Write the number under the verb. ____
10) Write the number under the first determiner. ____

Every day the black cat visits me.
1 2 3 4 5 6 7

11) Write the number under the verb. ____
12) Write the number under the first determiner. ____
13) Write the number under the pronoun. ____

I think that the dog in the car belongs to them.
1 2 3 4 5 6 7 8 9 10 11

14) Write the number under the second pronoun. ____
15) Write the number under the first noun. ____

He jumped over the fence and ran across the wet, green grass.
1 2 3 4 5 6 7 8 9 10 11 12

16) Write the number under the second noun. ____
17) Write the number under the first adjective. ____
18) Write the number under the second verb. ____

Subtest 3 - Noun Phrases and Double Verbs

Sample Questions	
A)	Circle the noun phrase.
	There is a new store near here.
B)	Circle the verb.
	I was thinking about you yesterday.

1) Circle the verb.
   Both Phyllis and Mary can read very well.
2) Circle the second noun phrase.
   I love to eat fresh fruit.
3) Circle the plural noun phrase.
   Some teachers like to come to school early.
4) Circle the verb.
   After school, Mary is going to San Francisco.
5) Circle the first noun phrase.
   You can have some dessert in the living room.
6) Circle the singular noun phrase.
   The men worked in the barn.
7) Circle the second verb.
   We were dancing and they were singing.
8) Circle the plural noun phrase.
   Four sheep escaped from the farm.

Subtest 4 - Choose Correct Determiner

Sample Questions
Circle the correct determiner.
A) You have [some, the] book I was reading.
B) [A, Four] boys are playing basketball.

Circle the correct determiner.

1) There is [a, an] elephant in my backyard.

2) I had [no, two] trouble finding your house.

3) [Every, All] computers make mistakes sometimes.

4) You may have [one, ten] cookie before dinner.

5) [A, Some] children don't have enough to eat.

6) He milked [a, three] cows before breakfast.

7) Lucy picked [every, six] f. wer she saw.

8) We are going to take [a, an] trip to Sacramento.

Subtest 5 - Singular and Plural Nouns

Sample Questions - Part 1

A) Write the plural of plum. ________

B) Write the singular of houses. ________

1) Write the plural of bush. ________
2) Write the plural of dinner. ________
3) Write the singular of feet. ________
4) Write the plural of telephone. ________
5) Write the singular of cries. ________
6) Write the singular of patches. ________
7) Write the plural of woman. ________
8) Write the plural of knife. ________
9) Write the singular of deer. ________
10) Write the plural of penny. ________

Sample Questions - Part 2

C) Circle the plural noun.
I lived on a farm for three years.

D) Circle the correct noun.
She has two [dollar, dollars] in her purse.

11) Circle the plural noun.
The flowers look pretty on the table.

12) Circle the singular noun.
The cat caught two mice.

13) Circle the correct noun.
Some [rabbit, rabbits] came out of that hole.

14) Circle the plural noun.
Mother fixed four lunches for our picnic.

15) Circle the correct noun.
The [child, children] were eating ice cream at the party.

16) Circle the correct noun.
I will give you three [guess, guesses].

Subtest 6 - Choose Correct Pronoun

Sample Question Grandpa bounced the baby on his knee. [He, They] bounced the baby on his knee. Circle the correct pronoun.

Circle the correct pronoun.

1) Some women like to live alone.
   [They, She] like to live alone.
2) Mike sent a letter to the queen.
   Mike sent a letter to [him, her].
3) The ice cream is very cold.
   [He, It] is very cold.
4) I played basketball with my brother.
   I played basketball with [him, he].
5) Her father invited me to dinner.
   [She, He] invited me to dinner.
6) Kathie made dinner for her friends.
   Kathie made dinner for [her, them].
7) My mother likes her job.
   [She, It] likes her job.
8) I saw that lady in a purple car.
   I saw [she, her] in a purple car.

Subtest 7 - Subject and Predicate

Sample Questions

A) Circle the predicate.
Father ate ten pancakes.

B) Circle the subject.
My friend gave me a big hug.

1) Circle the predicate.
A big storm is coming.

2) Circle the subject.
It was a happy day.

3) Circle the subject.
The furry black bear liked the peanuts.

4) Circle the predicate.
Your pet bird sings very well.

5) Circle the predicate.
Dean gave me a beautiful necklace.

6) Circle the subject.
Sally flew to Los Angeles with her uncle.

7) Circle the predicate.
Mother and I baked a birthday cake.

8) Circle the subject.
My best friend is from Mexico.

Subtest 8 - Adjective Transforms

Sample Question

There are three trees in front of our house. (The trees are big.)

A) There are three trees in front of our big house.
B) There are three big trees in front of our house.

Write the letter of the correct sentence: ____

1) Janice put on her coat and went out the door. (The coat was new.)

A) Janice put on her new coat and went out the door.
B) Janice put on her coat and went out the new door.

Write the letter of the correct sentence. ____

2) Three cats played with a ball in the yard. (The ball was brown.)

A) Three brown cats played with a ball in the yard.
B) Three cats played with a ball in the brown yard.
C) Three cats played with a brown ball in the yard.

Write the letter of the correct sentence: ____

3) One morning, Colin went for a run near the river. (The morning was cold.)

A) One morning, Colin went for a cold run near the river.
B) One cold morning, Colin went for a run near the river.
C) One morning, Colin went for a run near the cold river.

Write the letter of the correct sentence. ____

4) I have a surprise for you after school. (The surprise is wonderful.)

A) I have a surprise for you after wonderful school.
B) I have a surprise for wonderful you after school.
C) I have a wonderful surprise for you after school.

Write the letter of the correct sentence: ____

APPENDIX

Progress Report

OE Project No. 14-2280 | Grant No. OEG-0-70-4797(607)

Period: July 1, 1971 to September 30, 1971 | Date of Submission: October 30, 1971

Name of Institution: Stanford University
Stanford, California 94305

Title of Project: Computer-assisted Instruction in Mathematics and Language Arts for the Deaf

Name of Project Director: Prof. Patrick Suppes

Bureau of Education
for the Handicapped
Division of Research

1. Major activities and accomplishments during this period

Further lessons for the Language Arts for the Deaf course were written and coded during this period. All 200 lessons for the first year of the course are now written and 175 are completely programmed and available for student use.

Teletypes were installed in several new schools during August and September. Eight teletypes were installed in the Florida State School for the Deaf and the Blind in St. Augustine, Florida. Ten teletypes were installed in the Oklahoma School for the Deaf in Sulphur, Oklahoma. Teletypes were installed in six county-wide day schools for the deaf in Texas: four in Montrose Elementary School in Houston, two in Pfeiffer School in San Antonio, two in Skyline Career Development Center in Dallas, one in John B. Hood Junior High School in Dallas, two teletypes in Tarrant County Day School for the Deaf in Ft. Worth, and one in Beaumont Bi-Countywide Day School for the Deaf in Beaumont. The teletypes in the county-wide day schools in Texas and those in the Oklahoma School for the Deaf are operated from the Stanford computer via a small computer located at the Texas School for the Deaf in Austin.

Alterations were made in the program for the language arts course to experiment with three different teaching strategies. There are two experimental groups using each of the three strategies which vary in their reinforcement routines. Data is being collected for future analysis.

The pretest for the language arts course was expanded and rewritten, and was distributed to all of the participating schools during this period.

The program for the transformational grammar course was rewritten in such a way as to allow at least five students to use this course simultaneously. A new lesson assembler was also written for this course which will allow lessons to be produced more quickly.

A new teacher's handbook for CAI courses was written and distributed to all the participating schools. A supplement on the Language Arts for the Deaf course was also written and distributed.

By the end of September all of the schools that had participated during the spring, except the three schools in the Palo Alto Unified School District, were again operational. The new schools will be operational very soon.

2. Problems

None

3. Significant findings and events

None

4. Dissemination activities

None

5. Capital equipment acquisitions

Fifteen modified Model 33 teletypes and 12 Collins data sets were purchased.

6. Data collection

Detailed response data on each student's use of all CAI courses are being collected and stored. The daily report program on the Deaf Language Arts course was revised to give more information.

7. Other activities

Teaching training for all the new schools was done during this period. At the beginning of July, Mary Barefield (Curriculum Coordinator for Texas County-wide Day Schools) and Melissa Scott (Texas Education Association) came to Stanford for CAI orientation. At the end of July, Diane Gouch (Florida School for the Deaf) and Richard Youngers and Jack Garrison (Oklahoma School for the Deaf) came to Stanford for CAI orientation.

On September 15 a Teacher Workshop on the Language Arts course was held at the Texas School for the Deaf. On September 28 a similar workshop was held at the California School for the Deaf in Berkeley. On October 11-13 an orientation workshop was held at the Oklahoma School for the Deaf. On October 19-22 an orientation workshop was held at the Florida School for the Deaf.

8. Staff utilization

Mrs. Helen Chetin left the project. Miss Mary Hueners left the project. Mr. Robert Smith, research associate, rejoined the project to work on the transformational grammar course and on analysis of deaf writing samples. Miss Marney Beard was promoted to be responsible for all lesson programming on the language arts course. Miss Joanne Leslie began working full time and took on administrative responsibilities in addition to her curriculum writing.

9. Future activities planned for next reporting period

The first year of the language arts course will be completed and work will begin on the second year of the course. The language tests will be scored and analysis of this data will begin. Some evaluation of the use of the CAI courses during the 1970-71 school year will be done and detailed evaluation models for this school year will be prepared.

10. Certification

Signature of Contract Officer

Project Director

Date

Date

Progress Report

OE Project No. 14-2280 Grant No. OEG-0-70-4797(607)

Period: October 1, 1971 to December 31, 1971

Date of submission: February 14, 1972

Name of Institution: Stanford University
Stanford, California 94305

Title of Project: Computer-assisted Instruction in Mathematics and Language Arts for the Deaf

Name of Project Director: Prof. Patrick Suppes

Bureau of Education for the Handicapped, Division of Research

1. Major activities and accomplishments during this period:

Curriculum for the Language Arts for Deaf course was completed during this period with 200 lessons now available to the participating schools. All of the schools mentioned in the previous progress report were operational during this period.

Average student per day use of CAI courses was as follows:

School	Average
Kendall School for the Deaf	61
M.S.S.D.	49
Gallaudet College	14
Florida School for the Deaf	156
Bachrodt	9
San Jose High School	13
Hester School	11
Berkeley School for the Deaf	114
George Washington Junior High School	6
Texas School for the Deaf	174
Beaumont School District	15
Bexar School for the Deaf	33
Montrose School for the Deaf	82
Tarrant School for the Deaf	35
Skyline High School	22
Oklahoma School for the Deaf	103
John B. Hood Junior High School	14

Major work on evaluation of the use of IMSSS CAI courses by deaf students was begun during this period. A pretest on the language skills taught in the Language Arts for the Deaf course was given to about 500 students in participating schools who were registered for this course. In addition, the test was given to about 50 hearing students at the Brentwood School in East Palo Alto who are taking the language arts course and about 50 students at the Florida School for the Deaf who are taking the mathematics strands course but not the language arts course. The correction of these tests and the creation of computer files of test data were begun.

Preliminary evaluations of the use of the mathematics strands program at three schools during the 1970-71 school year were made during this period. These evaluations were based on both gains as indicated by the CAI program and gains as indicated by external tests. Specific findings are presented under Significant Findings and Events. Statistical models for the future evaluation were developed. One class of models varies the proportion of mathematics sessions to language sessions on the computer for different groups of students. Another class of models predicts the number of mathematics sessions for a certain student to achieve a specified grade level goal during a given period of time.

2. Problems:

None.

3. Significant findings and events:

Data on 51 students in the Palo Alto School District classes for the deaf were analyzed. The students used the IMSSS mathematics strands program for February through June, 1971, and were pre-and-post-tested with the IPI Mathematics Continuum as part of the regular school testing program. Both linear and nonlinear regressions were run and it was found that number of CAI sessions had a significant effect on IPI gain, as well as on CAI gain.

Data on 101 students at the Texas School for the Deaf who used the mathematics strands program during Spring, 1971 were analyzed. Students were tested with the Metropolitan Achievement Test in January 1969, January 1970, and May 1971 as part of the regular school testing program. It was found that the mathematics gains during the 1970-71 school year for these students were higher than during the 1969-70 school year, and further, that the number of CAI mathematics sessions correlated positively with MET gains.

Data on 172 students at the California School for the Deaf at Berkeley who used the mathematics strands program during Spring, 1971 were analyzed. Students were tested with the Stanford Achievement Test in May of 1969, 1970 and 1971 as part of the regular school testing program.

These data are inconclusive as far as effects of CAI are concerned, because gains on most of the SAT subtests were less during the 1970-71 school year than the 1969-70 school year.

A detailed analysis of the first 25 lessons of the Language Arts for the Deaf course was made based on responses of a sample of over 300 students who had done these lessons. These 25 lessons are on the language of directions as used in the following lessons on grammar and usage. Fourteen variables were identified in these lessons and a linear regression analysis was done to see which variables were most influential. It was found that the number of words in the instruction accounted for the most variance and that the number of characters in the correct response was next in importance.

4. Dissemination activities:

None.

5. Capital equipment acquisitions:

None.

6. Data collection:

Detailed response data on each student's use of all CAI courses are being collected and stored. The TALK program was modified to record only conversations between students. The Item Analysis I program was run on all student responses on the Language Arts for the Deaf course from February 11, 1971 through October 18, 1971. This program shows the total number of students who did each exercise in the course, and the percentage that answered correctly on the first try. This analysis will be used for future revision of the course.

7. Other activities:

Several visits to participating schools were made during this period. October 11-13, teacher workshops were given by Carolyn Stauffer at the Oklahoma School for the Deaf. October 14-15, Mrs. Stauffer attended the Wimberly Conference on county-wide day schools for the deaf in Texas. October 19-22, teacher workshops were given by Grace Kanz at the Florida State School for the Deaf and the Blind. From October 28 through November 10, teacher orientation at the Texas County-wide Schools for the Deaf was conducted by Lynda Culbertson and Mary Barefield of the Texas School for the Deaf. Teletype installation on maintenance trips were made October 6-15, to the Oklahoma State School for the Deaf, the Texas School for the Deaf and the Florida State School for the Deaf and the Blind. A teletype maintenance trip was made to the county-wide schools in Texas, November 15-19.

Jamey Friend and Dexter Fletcher visted the schools in Washington, D.C., November 28 through December 2 and the schools in Texas, December 5-7 to introduce Mr. Fletcher as new project coordinator.

During this period some preliminary analysis of deaf writing samples was done. The distribution of length of utterance was obtained and a dictionary of words in the corpus was made. These words were ranked by frequency of use and classified according to grammatical function.

Teachers at the Kendall School for the Deaf wrote various experimental lessons in language skills. These lessons were rewritten and coded to make them available as CAI. Experimental use of these lessons with Kendall students is planned.

8. Staff utilization:

Effective December 15, Mr. Dexter Fletcher replaced Mrs. Jamesine Friend as Curriculum Coordinator for the project. Mrs. Friend resigned from IMSSS because of an impending move from California. Mr. Fletcher's vita is enclosed with this report.

9. Future activities planned for next reporting period:

Experiments based on the evaluation models mentioned in section 1 will be set up in the participating schools. Both on-line and off-line pre-testing of students will be done in connection with these experiments. Research papers on the language arts curriculum and the analysis of deaf writing samples will be written. Data from the language arts pre-test will be analyzed and a parallel form post-test will be prepared.

Progress Report

OE Project No. 14-2280 Grant No. OEG-0-70-47[illegible] ([illegible])

Period: January 1, 1972 to March 31, 1972

Date of submission: April 25, 1972

Name of Institution: Stanford University
Stanford, California 94305

Title of Project: Computer-assisted Instruction in Mathematics and Language Arts for the Deaf

Name of Project Director: Prof. Patrick Suppes

[illegible]eau of Education
for the Handicapped,
Division of Research

1. Major activities and accomplishments during this period:

Two evaluation experiments concerning the use of the mathematics strands program in participating schools for the deaf were implemented. Experiment I will measure the effect of different numbers of math sessions on gain scores on a standardized computation test. Students whose average grade placement on math strands was between 2.4 and 5.9, who had completed at least 15 math sessions by January 7, 1972 and who were registered for the language arts course as well as for the math course were eligible for this experiment. The eligible students were assigned to one of five experimental groups. These groups were assigned 10, 40, 70, 100, and 130 math sessions respectively. The students recieve language arts lessons only when they are keeping up with the required number of math sessions for their group. Experiment I began on February 8, 1972 in the following schools with the number of students shown:

Kendall	-	43
Texas	-	89
Berkeley	-	80
Oklahoma	-	60
Tarrant	-	3
Beaumont	-	10
Skyline	-	5
John B. Hood	-	6
Montrose	-	27
Total	-	323

Experiment II is an attempt to determine how well we can predict the number of math sessions a student will need to attain an individually prescribed performance goal. Any student with an average grade placement between 2.0 and 5.9 who had completed 20 math sessions by January 7, was eligible for this experiment. Each student's initial performance goal was based on previous gain in average grade

placement on math strands. Periodically during the experiment we have been recalculating how many strands sessions per day each student must have to reach the goal set for him. 105 students at the California School for the Deaf at Berkeley, 100 students at the Texas School for the Deaf and 162 students at the Florida School for the Deaf are participating in Experiment II, which started on February 14. All students participating in either experiment took a modified version of the Stanford Achievement Test (SAT) given by computer at the end of January. A third experiment to test the concurrent validity of the modified SAT with the paper and pencil SAT was also undertaken.

The scoring of the language pretests was completed and individual item responses for all students were entered into computer data files. After incomplete tests were eliminated, we had data for 519 tests. Preliminary analysis of this test data will be discussed in section 3.

An item analysis program was completed and run for student responses on the G-course (Language Arts for the Deaf) over the period October 26, 1971 through February 26, 1972. This analysis gives for each item in the course 1) number of students who responded 2) number who gave a correct first response 3) the percentage who gave a correct first response and 4) number who asked to be given the correct answer.

A language arts course report was completed to give for any class of students over any period of time, the language arts lessons each student had completed, number of exercises in each lesson the student completed, percentage of completed exercises in each lesson that were correct, and an ordinal indicating when in his sequence of lessons the student took each lesson.

Under separate funding, two teletype terminals were installed in February at the Fairmeadow School in Palo Alto for use by students in the Program for the Deaf and Hard-of-Hearing of the Palo Alto Unified School District. 63 students from grade 1 through grade 8 are registered for the math strands program and/or the language arts course.

2. Problems:

None.

3. Significant findings and events:

Language pretest data for 519 students were analysed. For each student we obtained the number of correct responses, the number of incorrect responses, the number of items with no response and the percentage correct of the total items. Including sample items, there were a total of 129 items on the test. The high score was 127, the low score was 12, the mean score was 86.1 (67%) and the standard deviation was 22.3. The analysis also gave the number of correct, incorrect and omitted responses for each item providing a basis for comparing the difficulty of the test items. One unexpected finding was that there were a large number of incorrect and omitted responses on the sample items.

The item analysis on the items in the G-course itself gave a basis for comparing the difficulty of the items within a lesson and among lessons. Also this

analysis indicated the relative difficulty of lessons in the course. For example, student performance on all items in lessons on pronouns seemed to show that the topic was already well understood.

4. Dissemination activities:

None.

5. Capital equipment acquisitions:

None.

6. Data collection:

Data on student performance on all CAI courses used in participating schools continued to be collected and stored. A questionnaire was sent to all participating schools requesting information about language and math curriculums and testing programs. Similar questionnaires were sent to many non-participating schools for the deaf requesting information about their language testing programs and language curriculums.

7. Other activities:

Several visits to participating schools were made during this period. February 9-20 Mrs. Grace Kanz gave teacher workshops at the Florida School for the Deaf, the Texas School for the Deaf and the Pfeiffer School in San Antonio, Texas. February 18-21 Mrs. Carolyn Stauffer gave teacher workshops at the other county-wide schools for the deaf and attended the Conference of County-Wide Schools for the Deaf in San Antonio. February 10-21 a teletype repair and maintenance trip was made to the participating schools in Texas. February 29-March 2, Mr. Dexter Fletcher went to Austin to discuss the math experiments with members of the staff of the Texas School for the Deaf. March 13-16, Mr. Fletcher and Mrs. Stauffer visited the participating schools in Washington, D.C., and also visited the National Technical Institute for the Deaf in Rochester.

Work continued on the experimental CAI lessons written by teachers at the Kendall School.

8. Staff utilization:

Mr. Dave Voorhees, who worked part time for this project, left IMSSS at the beginning of January. The secretarial staff changed during this period; Miss Nancy Stinson joined the project at the beginning of January as a half-time secretary, and Mrs. Chris Spraker left the project as a half-time secretary at the end of March.

9. Future activities planned for next reporting period:

Posttesting for both the mathematics experiments and the language testing program will be completed in May, 1972. Two revised forms of the language test

will be prepared as parallel forms which will be given to about 80 students during the posttesting period. A technical report on the IMSSS CAI language program will be written. Revisions of the G-course will be planned based on item analyses of both the course and the language test, and results of the experiments in which different groups of students on the course receive different patterns of correction messages will be determined.